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ABSTRACT

This paper identifies, structures, and defines a list of cost elements that is intended to describe fully the life-cycle cost of any formal program, course, or device for individual training of Department of Defense personnel. It was developed to provide consistent, comparable, and credible evaluations of the cost-effectiveness of alternative methods of training. Following a summary and introduction, the cost element structure is presented in a table with cost elements grouped by cost category (research and development, initial investment, operating and support). Definitions of the cost elements are then presented in the order that they appear in the table. Another table illustrates the applicability of each cost element in table 1 to three types of training evaluated in previous studies: the cost effectiveness of flight simulators, computer based instruction, and maintenance simulators. A brief discussion and a 30-item reference list are included. Appendices provide a glossary of terms relevant to cost analysis and a discussion of relationships between cost elements for training and Department or Defense budget appropriations. (Author/LMM)

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A COST ELEMENT STRUCTURE FOR DEFENSE TRAINING

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November 1983

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This paper identifies, structures, and defines a list of cost elements that is intended to describe fully the life-cycle cost of any formal program, course, or device for individual training of DoD personnel, regardless of the conditions or assumptions imposed by the particular application or problem of interest. It was developed to satisfy a widely-recognized need for consistent, comparable, and credible evaluations of the cost-effectiveness of alternative methods of training.

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Training is a necessary and expensive activity needed to maintain military readiness. The Defense Science Board has recommended that cost-effectiveness evaluations of military training be performed to optimize the use of available training resources and to support investments in new training programs, equipment and technologies. The Board found that data needed to develop and evaluate training programs are inadequate; this perpetuates the weak position of training in competing for funds, and in demonstrating its value. Our review of the cost analyses in well over 100 studies of defense training was consistent with the Board's finding.

This cost element structure was developed with reference to a number of authoritative and widely-used cost guides issued by and for the training and weapon systems communities of the Services and offices of the Secretary of Defense. It also incorporates many recommendations of reviewers involved in related functions and activities.

The general use of a comprehensive cost-element structure such as this would offer several advantages for evaluating the costs of institutional training programs, courses, and devices.

1. Used as a guide to estimate costs, it would ensure that all costs incurred during the life cycle (or period of interest) of a training program, course, or device would be accounted for. Gaps in essential data may be identified in this way.

2. It would permit making comparisons among training options that are reliable and that can be used with confidence.

3. The level of detail should be adequate to:

   a. Identify the cost elements that account for the major costs, thus focusing attention on areas for significant cost reduction or for trade-off analyses between high-cost items and training effectiveness.

   b. Enable individuals with specific responsibilities that interact with training (e.g., budgeteers, manpower planners, procurement specialists) to focus on specific elements of primary interest to them and to evaluate the implications of those resources in a total-program context.

   c. Assist in identifying significant variables for use in the development of cost-estimating relationships applicable to training programs.

4. It should enhance communication and understanding among people concerned with various aspects of weapon system programs on subjects of mutual concern.

FOREWORD

This paper is an attempt to identify and structure a list of cost elements that captures all costs needed to conduct life-cycle cost-effectiveness analyses of alternative military training programs, courses, and devices for the institutional training of U.S. personnel, regardless of the conditions or assumptions imposed by the particular application or problem of interest. A cost element structure (CES) designed for this objective may not apply (without some modification) to: (a) the training of foreign military students; (b) field training detachments and on-the-job training in operational commands; (c) training exercises in and/or by operational commands; (d) residencies, fellowship programs, and non-resident and correspondence courses; and (e) the determination of total budget requirements for the training systems, courses, or devices of interest.

The main need for such a definitive CES relevant to military training is to enable consistent and credible evaluations of the cost-effectiveness of alternative training programs.

An earlier draft of this paper was distributed widely throughout the defense training community and headquarters of the military departments to solicit suggestions for making the proposed CES more comprehensible and suitable for use by individuals concerned with military training throughout the Department of Defense.

Thoughtful and constructive critiques were received from over 30 individuals in the three military departments and several companies. Many of their recommendations are reflected in this paper.

The most significant comments can be grouped in seven categories regarding the development of a common CES for use in cost-effectiveness (C-E) analyses. These categories are identified and discussed briefly in the following paragraphs.

1. The need for a standardized, comprehensive CES applicable to training programs, courses, and devices.

Well over half of the reviewers acknowledged a long-standing need for a standardized CES for use by the military training community to improve relevance, completeness, and comparability of costs among alternatives; to provide a common basis for cost data generation and collection; and to improve communication among the various organizations concerned with training.

2. Adaptability of a weapon-system-based CES to training programs, courses, and devices.

The CES proposed in the draft version of this paper was based on the time-honored weapon system CES. About one-third of the respondents questioned the practicality of basing a training CES upon the generally accepted weapon system CES. Aided by comments and documents furnished by the respondents, the CES in this paper incorporates substantial modifications to accommodate functions, activities, and resources that are typical of military training.

3. The (a) availability of relevant cost data, and (b) impact of a new CES on existing accounting systems.

About one-third of those who reviewed the draft paper expressed concern about one or both of these subjects. Obviously, the two are interrelated.

The requirement for a general method for estimating the cost-effectiveness of alternative training modes led to the formulation of a comprehensive cost element structure that, when refined, should be usable throughout the training community. The use of a common CES need not

require changes in existing accounting systems. It is recognized that differences in accounting systems, nomenclature of cost elements, and data requirements and data collection procedures among (and within) the Services preclude precise and complete correspondence between financial data and cost elements for all C-E analyses among all Services. If, however, there is to be comparability among C-E analyses of alternative courses of action and, if credibility in the analyses that support requests for implementation is to be reasonably assured, reference to a standard CES is advantageous. A standard CES, however, no matter how comprehensive, is not a surrogate for good judgment in C-E analyses. To make certain that all pertinent costs are included in C-E analyses, it would be appropriate for C-E analysts to specify those elements of the standard CES that may be omitted as irrelevant, and pertinent elements that are implicit in elements that may be titled differently to maintain consistency with Service-peculiar cost accounting systems.

4. The degree of emphasis by upper management.

A number of reviewers attributed shortcomings in C-E analyses of training more to insufficient top-management emphasis than to a lack of appropriate C-E methodology. It may be expected that implementation of the recommendations made by the Defense Science Board in their recent Summer Study, *Training and Training Technology* (November 1982), will provide added impetus to the development of more rigorous C-E analyses of alternative training methods and a repository for data on the costs and effectiveness of various types of military training.

5. References to Interservice Training Review Organization (ITRO) cost analysis procedures and model.

A number of reviewers referred to existing and proposed ITRO documents as guidance for the development of a standardized CES. At the same time, they acknowledged that since ITRO's

principal goal is the realization of cost savings that may result from collocation or consolidation of training courses among the Services, ITRO's cost analysis methodology is not adequate for cost-effectiveness analyses based upon life-cycle costs. ITRO's approach omits the R&D and many of the Initial Investment costs that are contained in the comprehensive life-cycle cost structure that is the subject of this paper. The Operating and Support cost category of this CES, however, is based, in large part, on ITRO's proposed "Services Standard Course Cost Procedures Handbook."

6. The relationship between cost elements and the appropriations by which the elements would be funded.

A few reviewers felt that information relating the cost elements to budget appropriations would enhance communication among cost analysts, budgeteers, training managers, and other decision makers. An attempt to develop cost element-to-appropriation relationships (often called a "cross-walk") is the subject of Appendix B.

7. The need for other cost elements, definitions, and clarification of terms used.

Many recommendations of this nature were adopted for this paper. "Depreciation," although considered in some Service procedures for cost analysis of military training, is not included in this proposed CES. Depreciation may be appropriate as an element of economic analysis, but it serves no purpose in a C-E analysis that compares the annual, future expenditures which would be incurred for alternative methods of achieving a training objective.

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We gratefully acknowledge the thoughtful and constructive critiques of an earlier draft of this paper by many members of the U.S. defense training community, headquarters of the military departments, and several companies. In addition, we are thankful for the advice and guidance of several officials of the Office of the Secretary of Defense (Comptroller).

We hope that those named below who reviewed the initial draft will find improvements in this paper that reflect their assistance.

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CONTENTS

Foreword iii
Acknowledgments vii
Abbreviations xv
SUMMARY S-1
A. Purpose S-1
B. Background S-1
C. The Cost Element Structure S-2
D. Advantages of the Cost Element Structure S-3
I. INTRODUCTION 1
A. Purpose 1
B. Background 2
II. COST ELEMENT STRUCTURE 5
A. Approach 5
B. A Proposed Cost Element Structure Applicable to Training 7
III. DEFINITIONS OF COST ELEMENTS 23
A. Research and Development 26
B. Initial Investment 33
C. Operating and Support 39
IV. APPLICATION OF PROPOSED COST ELEMENT STRUCTURE TO TRAINING PROGRAMS, COURSES, AND DEVICES 49
V. DISCUSSION 55
References 59

APPENDIX A - Glossary of Terms Relevant to Cost Analysis A-1

APPENDIX B - Relationships Between Cost Elements for Training and Department of Defense Budget Appropriations B-1

TABLES

1. A Comprehensive Cost Element Structure for Military Training Programs, Courses and Devices 8

2. Illustrative Application of the Comprehensive Cost Element Structure for Military Training Programs, Courses, and Devices 50

ABBREVIATIONS

ATC	Air Training Command
C-E	Cost-Effectiveness
CER	Cost-Estimating Relationship
CES	Cost Element Structure
CNET	Chief of Naval Education and Training
CONUS	Continental United States
CPFF	Cost-Plus-Fixed-Fee
DoD	Department of Defense
DT/IOT&E	Development Test/Initial Operational Test and Evaluation
DT/OT	Developmental Test/Operational Test
ECO	Engineering Change Order
ECP	Engineering Change Proposal
FFP	Firm Fixed-Price
FPIF	Fixed-Price Incentive-Fee
FYDP	Five-Year Defense Program
GFE	Government-Furnished Equipment
GOE	Government-Owned Equipment
ISD	Instructional System Development
ITRO	Interservice Training Review Organization
O&M	Operations and Maintenance
O&S	Operating and Support
OSD	Office of the Secretary of Defense
P&A	Pay and Allowances
P/C/D	Training Program, Course, or Device
PCS	Permanent Change of Station
POL	Petroleum, Oils and Lubricants
R&D	Research and Development
RDT&E	Research, Development, Test, and Evaluation

TDY	Temporary Duty
T&E	Test and Evaluation
TOA	Total Obligational Authority
TRADOC	Training and Doctrine Command
WBS	Work Breakdown Structure

SUMMARY

A. PURPOSE

This paper identifies, structures, and defines a list of cost elements that is intended to describe fully the life-cycle cost of any formal program, course, or device for individual training of DoD personnel, regardless of the conditions or assumptions imposed by the particular application or problem of interest.[1]

The principal need for such a definitive cost element structure (CES) relevant to military training is to enable consistent and credible evaluations of the cost-effectiveness of alternative methods of training.

B. BACKGROUND

Training is a necessary and expensive activity needed to maintain military readiness. In fiscal year 1984, for example, individual training at Service schools was estimated to cost $13.4 billion and to account for about 20 percent of all manpower allocated to the Services.

The Defense Science Board, in 1976 and again in 1982, recommended that cost-effectiveness evaluations of military training be performed to optimize the use of available training

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[1]This study was performed for the Office of the Deputy Under Secretary of Defense for Research and Engineering (Research and Advanced Technology) under the technical cognizance of the Military Assistant for Training and Personnel Technology, and for the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) under the technical cognizance of the Director, Training and Education. The technical officers were Captain Paul R. Chatelier (USN) and Michael Kendall, respectively. Gary Boycan is the current technical officer at MRA&L.

resources and to defend investments in new training equipment and technologies. The Board found that data needed to develop and evaluate training programs are inadequate; this perpetuates the weak position of training in competing for funds, and in demonstrating its value.

Our review of the cost analyses in well over 100 studies of defense training was consistent with the Board's finding. We observed that cost data are often fragmentary, are too highly aggregated, and are not always comparable. Furthermore, we found that the use of formal cost models is not documented in most studies on the cost-effectiveness of defense training; yet, a formal cost model is essential to credible cost-effectiveness analysis.

In general, it appears that no standardized methodology for analysis of training costs has been developed, nor have cost data been acquired in accordance with a common set of definitions.

C. THE COST ELEMENT STRUCTURE

A necessary early step in the formulation of any cost-effectiveness model is the identification and logical organization of the functional elements of cost that constitute life-cycle cost so that alternatives can be compared equitably. This paper is intended to provide such a structured list of cost elements.

This CES, and the cost-effectiveness model(s) of which it would become a part, would be used by acquisition and manpower planners, and developers of weapon and support systems to estimate the cost-effectiveness of alternative ways to train operational and maintenance personnel. With its intended use in mind:

1. This CES, and the associated definitions, were developed with reference to a number of authoritative and widely-used cost guides issued by and for the training and weapon system

communities of the Services and offices of the Secretary of Defense. Its use as a guide in the conduct of cost analyses should have minimum impact on existing financial structures and cost-accounting procedures.

2. It should be sufficiently comprehensive and detailed to:

a. Capture all elements of the life-cycle cost of any training program, course, or device, regardless of its size, complexity, or cost.

b. Permit identification of cost elements that are the major contributors to total cost.

c. Enable individuals with singular interests (e.g., manpower planners, training and procurement specialists) to identify resources of particular interest to them, and to evaluate the implications of those resources in a total-program context.

3. The cost elements are function-, activity-, and resource-oriented to permit their integration with work-breakdown structures (WBS) that are unique to various training programs, courses, and devices.

4. An earlier draft of this paper was distributed widely throughout the defense training community and headquarters of the military departments to solicit suggestions for improving its comprehensibility and suitability. Many of their recommendations are reflected in this paper.

D. ADVANTAGES OF THE COST ELEMENT STRUCTURE

The general use of a comprehensive cost element structure for military training, such as the one proposed in this paper, would offer several advantages for evaluating the costs of training programs, courses, and devices.

1. Used as a guide to estimate costs, it would ensure that all costs incurred during the life cycle (or period of interest) of a training program, course, or device would be accounted for. Gaps in essential data may be identified in this way.

2. It would permit making comparisons among training options that are reliable and that can be used with confidence.

3. The level of detail should be adequate to identify the cost element(s) that account for the major costs of a training program, course, or device. Identification of major costs, i.e., "cost drivers," would permit one to focus attention on areas for significant cost reduction or for trade-off analyses between high-cost items and effectiveness. It should also assist in identifying significant variables for use in the development of cost-estimating relationships.

4. This CES is a synthesis of cost analysis guidance of the weapon-system and training communities of the Services and offices of the Secretary of Defense. As such, its general use should enhance communication and understanding among people concerned with various aspects of training (e.g., procurement, manpower, providing the training) and those involved with other aspects of weapon system programs on subjects of mutual concern (e.g., cost estimates, trade-offs between cost and effectiveness of alternative training programs, and the allocation of resources among mission areas, systems, and programs).

I. INTRODUCTION

A. PURPOSE

The purpose of this paper is to identify and structure a list of cost elements that will describe fully the life-cycle cost of any formal program or course, or device for individual training of U.S. personnel, regardless of the conditions or assumptions imposed by the particular application or problem of interest. The focus on formal, individual training (also referred to as institutional training) omits consideration of training in operational mission units, field training detachments, on-the-job training, residencies (including the Service academies), fellowship programs, and non-resident and correspondence programs.

The main need for such a definitive cost element structure (CES) is to enable consistent and credible evaluations of the costs of alternative means to satisfy a specific training requirement.

This paper is part of an effort to satisfy a recognized need for a general method that can be used by acquisition and manpower planners, and developers of weapon and support systems in and for the military Services, to estimate the cost-effectiveness of alternative ways to train operational and maintenance personnel. The general use of such a method should assist policymakers and decisionmakers at various levels in the Services and the Office of the Secretary of Defense (OSD) to make more credible judgments concerning the efficient allocation of resources available for military training.

Since this is an early effort, it is anticipated that this cost element structure will be modified and improved on the basis of experience with its use.

B. BACKGROUND

Training is a necessary and expensive activity needed to maintain military readiness. In fiscal year 1984, for example, individual training at Service schools was estimated to cost $13.4 billion and to account for about 20 percent of all man-years allocated to the Services [Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics, 1983)].[1] Both the cost and effectiveness of formal, individual military training are examined by the Congress, the OSD, and the individual Services (e.g., Defense Science Board 1982, Orlansky and String 1979 and 1981, String and Orlansky 1977). Attention has been directed towards the cost and effectiveness of flight simulators, computer-based instruction, unit training, and field exercises.

Our review of the cost analyses in well over 100 studies of training in the last six years reveals some fundamental deficiencies that limit meaningful cost-effectiveness comparisons among alternatives:

1. The use of formal cost models is not documented in most studies on the cost-effectiveness of military training systems; yet a formal cost model is essential to credible cost-effectiveness analysis. Without explicit identification of all relevant costs and assumptions, one cannot be certain that alternatives are compared in a consistent manner.

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[1]See complete references at the end of this paper.

2. Available cost data are fragmentary, are too highly aggregated, and are not always comparable. Reasons for these shortcomings include the following:

   a. The apparent lack of reliance on formal cost models that include standardized definitions of cost elements.[1]

   b. The acquisition costs of many training programs (e.g., computer-based instruction) fall below the threshold of "major" programs for which contractors are required to use prescribed formats in periodic cost reports.

   c. Training equipment is often procured via firm fixed-price (FFP) and fixed-price incentive-fee (FPIF) contracts. Such contracts provide the Services little leverage in the specification of cost detail. Even when cost-plus-fixed-fee (CPFF) contracts have been employed, the Services' project offices have not always required contractors to furnish cost data in standardized formats.

In general, it appears that no standardized methodology for analysis of training costs has been developed, nor have cost data been acquired in accordance with a common set of definitions.

[1]Definitions of cost elements are not given in the majority of studies of military training costs reviewed to date.

II. COST ELEMENT STRUCTURE

A. APPROACH

A necessary early step in the formulation of any cost-effectiveness model is the delineation and logical organization of the functional elements of cost that constitute life-cycle cost so that alternatives can be compared equitably. This paper is intended to provide such a structured list of cost elements.

Several criteria and ground rules were adopted to guide development of the cost element structure (CES) in this paper.

1. Scope of the CES

This CES should be sufficiently comprehensive to capture all elements of the life-cycle cost of any institutional training program, course, or device (p/c/d), regardless of its size, complexity, or cost. The level of detail should be adequate to identify the cost elements that are the major contributors (i.e., the "cost drivers") to the total cost of a p/c/d.

2. Principal Use

This CES, and the cost-effectiveness model(s) of which it would become a part, would be used principally in planning for alternative, new training p/c/d's, and in evaluations of substantial modifications to existing p/c/d's.

3. Definition of "Cost"

In choosing among alternative programs, courses, or devices designed to satisfy a particular training requirement, decision-makers will be concerned with the future expenditures of DoD resources to acquire and/or operate each alternative. In this context, "cost" is defined as future expenditures of DoD resources occasioned by the design, development, implementation, and/or operation of a training p/c/d.

4. Consideration of Service Financial/Cost Accounting Procedures

The Services use various procedures to estimate training costs. A priori, the methods in use are compatible with their financial and cost accounting procedures. While those methods may be adequate for the Services' internal use, they comprise cost elements that are not always understood or accepted throughout the defense training community, and at the DoD level where final decisions are made on allocations of limited resources among the Services, mission areas, systems, and activities. One criterion observed in the development of this CES was that its adoption should not necessitate changes in existing financial and accounting systems. Accordingly, it was formulated with reference to a number of DoD and Service cost/economic analysis guides and procedures.

5. Consideration of Work Breakdown Structures

A defense system or item of major equipment is described by its discrete segments (i.e., components or subsystems) to facilitate management planning and control of the R&D and production phases of its life cycle. The procedure is formalized as a work breakdown structure (WBS) that is tailored to the particular system or equipment of interest (Department of Defense, MIL-STD-881, 1968). This practice usually is applied to training p/c/d's of substantial size and complexity (e.g., a

trainer aircraft, a weapon system simulator). The CES developed in this paper is intended to apply to any institutional training p/c/d, regardless of its type, size, complexity, or materiel content. It is impractical, therefore, to anticipate WBSs suitable to all p/c/d's; hence, the cost elements in this CES are function-, activity-, and resource-oriented. It is left to those concerned with analysis of individual p/c/d's to select pertinent cost elements from this structure and to integrate them into the p/c/d WBSs.

B. A PROPOSED COST ELEMENT STRUCTURE APPLICABLE TO TRAINING

The comprehensive cost element structure presented in Table 1 was constructed so that relevant elements can be selected to describe fully the life-cycle cost (or portion thereof) of any training program, course, or device, regardless of the constraints, assumptions, or other conditions imposed by the particular application or problem presented. It is expected that suggestions for improvement would result from experience with its use.[1]

The cost elements are grouped by cost category. Cost elements in the Research and Development and Initial Investment categories are based on those that have been used throughout the Department of Defense for many years to detail the acquisition costs of weapon systems. They have been modified, however, to accommodate functions, activities, and resources that are typical of military training. Training course cost guidance developed by the Interservice Training Review Organization (ITRO) was instrumental in the generation of the Operating and Support category. Some training p/c/d's are unique to specific weapon systems. Other training course materials and equipment are developed for general types of training at schools.

[1]An earlier draft of this paper was reviewed by about 30 members of the defense training community and headquarters of the military departments. Many of their comments and recommendations are reflected in this paper.

Table 1. A COMPREHENSIVE COST ELEMENT STRUCTURE FOR MILITARY TRAINING PROGRAMS, COURSES, AND DEVICES

A. RESEARCH AND DEVELOPMENT

1. Design

a. Pay and Allowances

(1) Military
(2) Civilian

b. Other Government Personnel Costs

(1) Military
(2) Civilian

c. Other

2. Component Development

a. Pay and Allowances

(1) Military
(2) Civilian

b. Other Government Personnel Costs

(1) Military
(2) Civilian

c. Other

3. Producibility Engineering and Planning

a. Pay and Allowances

(1) Military
(2) Civilian

b. Other Government Personnel Costs

(1) Military
(2) Civilian

c. Other

4. Tooling

a. Pay and Allowances

(1) Military
(2) Civilian

Table 1 (continued)

b. Other Government Personnel Costs

(1) Military
(2) Civilian

c. Other

5. Prototype Manufacturing

a. Pay and Allowances

(1) Military
(2) Civilian

b. Other Government Personnel Costs

(1) Military
(2) Civilian

c. Other

6. Data

a. Managerial Data

(1) Pay and Allowances

(a) Military
(b) Civilian

(2) Other Government Personnel Costs

(a) Military
(b) Civilian

(3) Other

b. Technical Data

(1) Pay and Allowances

(a) Military
(b) Civilian

(2) Other Government Personnel Costs

(a) Military
(b) Civilian

(3) Other

Table 1 (continued)

7. P/C/D Test and Evaluation

   a. Pay and Allowances

      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs

      (1) Military
      (2) Civilian

   c. Other

8. System/Project Management

   a. Pay and Allowances

      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs

      (1) Military
      (2) Civilian

   c. Other

9. Facilities

10. Other

Table 1 (continued)

B. INITIAL INVESTMENT

1. Production

a. Nonrecurring

(1) Production Planning
(2) Production Tooling and Equipment
(3) Industrial Facilities
(4) Other

b. Recurring

(1) Manufacturing
(2) Sustaining Engineering
(3) Sustaining Tooling
(4) Quality Assurance
(5) Other

c. Initial Spares and Repair Parts

2. Engineering Changes

3. Purchased P/C/D - Peculiar Equipment

4. Common Equipment

5. Data

a. Managerial Data

(1) Pay and Allowances
(2) Other Government Personnel Costs
(3) Other

b. Technical Data

(1) Pay and Allowances
(2) Other Government Personnel Costs
(3) Other

c. Instructional Materials

(1) Pay and Allowances
(2) Other Government Personnel Costs
(3) Other

Table 1 (continued)

6. Training P/C/D Test and Evaluation
   a. Pay and Allowances
   b. Other Government Personnel Costs
   c. Other
7. System/Project Management
   a. Pay and Allowances
   b. Other Government Personnel Costs
   c. Other
8. Rents
9. Operational/Site Activation
10. Initial Training
   a. Instructors
   b. Maintenance Personnel
11. Transportation
   a. First-Destination
   b. Second-Destination
12. Other

Table 1 (continued)

C. OPERATING AND SUPPORT

1. Direct Costs

a. Instructional Costs

(1) Pay and Allowances

(a) Instructors
1 Military
2 Civilian

(b) Supervisors, Administrators and Support Personnel
1 Military
2 Civilian

(c) Maintenance Personnel
1 Military
2 Civilian

(2) Other Government Personnel Costs

(a) Military

(b) Civilian

(3) Consumption

(a) POL

(b) Training Munitions

(c) Utilities
1 Electric Power
2 Other

(d) Instructional Materials

(e) Other

(4) Replenishment Spares

(5) Modification Materiel

(6) Depot Maintenance

(a) Labor and Materials

(b) Second Destination Transportation

(c) Other

Table 1 (continued)

(7) Other Purchased Services

(8) Other

b. Training Activity Costs

(1) Pay and Allowances

(a) Military

(b) Civilian

(2) Other Government Personnel Costs

(a) Military

(b) Civilian

(3) Other

(a) Consumables

(b) Other

c. Airfield and Carrier Operations Costs

(1) Pay and Allowances

(a) Military

(b) Civilian

(2) Other Government Personnel Costs

(a) Military

(b) Civilian

(3) Other

d. Student Costs

(1) Pay and Allowances

(a) Military

(b) Civilian

(2) Other Student Costs

Table 1 (continued)

(a) Military

(b) Civilian

e. Other Direct Costs

2. Indirect Costs

a. Base Operations

(1) Pay and Allowances

(a) Military

(b) Civilian

(2) Other Government Personnel Costs

(a) Military

(b) Civilian

(3) Other

b. Inventory and Supply Management

(1) Pay and Allowances

(a) Military

(b) Civilian

(2) Other Government Personnel Costs

(a) Military

(b) Civilian

(3) Other

c. Military Family Housing Support

(1) Pay and Allowances

(a) Military

(b) Civilian

(2) Other Government Personnel Costs

Table 1 (continued)

(a) Military

(b) Civilian

(3) Other

d. Command Support Costs

(1) Pay and Allowances

(a) Military

(b) Civilian

(2) Other Government Personnel Costs

(a) Military

(b) Civilian

(3) Other

e. Other Indirect Costs

Nevertheless, it is felt that this CES, which reflects cost-estimating procedures of the weapon system and military training communities, can be applied to all types of institutional training programs, courses, and devices.

The proposed cost element structure, and the associated definitions, are derived from the following authoritative and widely used cost guides:

Department of the Army

Research and Development Cost Guide for Army Materiel Systems, Pamphlet No. 11-2, May 1976

Investment Cost Guide for Army Materiel Systems, Pamphlet No. 11-3, April 1976

Operating and Support Cost Guide for Army Materiel Systems, Pamphlet No. 11-4, April 1976

Weapon/Support Systems Categories and Elements, AR37-18, 15 October 1971

Office of the Assistant Secretary of Defense (Comptroller)

Economic Analysis and Program Evaluation for Resource Management, DoDI 7041.3, October 1972

Uniform Budget/Cost Terms and Definitions, DoDI 5000.33, August 1977

Accounting Guidance Handbook, 7220.9-H, October 1981

Cost Analysis Improvement Group (OSD)

Aircraft Operating and Support Cost Development Guide, April 1980

Naval Training Equipment Center (U.S. Navy)

Cost and Schedule Estimating System (CES), January 1983

Project Manager for Training Devices (U.S. Army)

Task Report for Development of Cost Estimating Relationships (CER) for Support of the Enhanced Cost Collection System, July 1981

Logistics Management Institute

Aircraft System Operating and Support Costs: Guidelines for Analysis, March 1977

The elements in the Operating and Support cost category were adapted, in large part, from the ITRO's proposed joint-Service regulation, Services Standard Training Course Costs, and its associated (draft) Services Standard Training Course Cost Procedures Handbook.

The elements listed in Table 1 and the definitions that follow are stated in general terms in order to accommodate differences in terminology among the Services. For the purpose of cost-effectiveness (C-E) analysis, this cost structure is meant to capture all relevant costs to the government[1] that may be incurred throughout the life-cycle of a training p/c/d. How the costs would be funded (Budget Appropriation, Budget Code, etc.) is incidental to C-E analysis.[2]

While the structure in Table 1 is designed to encompass the life-cycle costs of a training p/c/d, the format permits individuals with narrower interests to focus on specific cost elements or groups of elements. It enables budgeteers, manpower planners, and training and procurement specialists, for example, to identify the resources of primary concern to each of them, and to evaluate the implications of those resources in a total-program context. Operating and Support (O&S) costs, for example, have been the subject of cost containment in recent years. In personnel-intensive programs and courses typified by many types of training (e.g., computer-assisted and conventional group instruction), O&S costs incurred during

[1]"...costs to the government...." include both payments to contractors and expenses for government resources (e.g., military personnel, civil servants, government laboratories, living quarters). See Section III, "Definitions of Cost Elements," for further discussion.

[2]The relationships between these cost elements and budget appropriations are the subject of Appendix B.

years of ongoing instruction could exceed substantially the costs of course design and development (R&D) and implementation (Initial Investment). The breakdown of the Operations and Support category provides for the many costs that are associated with personnel who are both directly and indirectly involved in the operations phase of a training p/c/d. In addition to the obvious costs of pay and allowances, the sub-element "Other Government Personnel Costs" (which is correlative to "Pay and Allowances") includes other costs that are properly attributable to the assignment of individuals to a training p/c/d.[1] Among these are Permanent Change of Station (PCS) and Temporary Duty (TDY) costs, which may be estimated based upon program characteristics such as numbers of personnel, frequencies of moves, intensity of program-related business travel, etc. On the other hand, other personnel-related costs [e.g., Personnel Replacement, Health Care, and Base Operations (element C.2.a)] would be allocated, usually on a per capita basis, by each Service. Where equipment costs are dominant in the R&D and Initial Investment phases of a training p/c/d (e.g., an aircraft intended solely as a trainer), the proposed CES provides appropriate cost elements (e.g., elements A.1, 2, 3, and 4, and B.1.a and b) to be applied to each major subsystem in the WBS (e.g., airframe, engine, and avionics). In this way, high-cost subsystems can be identified for possible cost reduction or intra-system trade-off analysis.

Since this CES was developed to capture all elements of the life-cycle cost of any training p/c/d, regardless of its size, complexity, or cost, it is necessary to include cost elements typical of the largest, most complex, and most costly p/c/d's (e.g., Undergraduate Pilot Training). The result is a lengthy list of elements, many of which would not be applicable to cost analyses of less extensive training p/c/d's. If, for

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[1]For details, see the beginning of Section III, "Definitions of Cost Elements."

example, the subject of C-E analysis were computer-based instruction in a schoolhouse environment, the costs of Airfield and Carrier Operations (element C.2.c) and POL and Training Munitions [elements C.1.a.(3)(a) and (b)] would be irrelevant. Obviously, the applicability of each of the cost elements in this CES would be dependent upon the nature and types of the alternative p/c/d's under consideration.[1]

Differences in nomenclature of cost elements, accounting systems, and data collection procedures among (and within) the Services preclude precise and complete correspondence between financial data and cost elements for all C-E analyses among all Services. Furthermore, data at the level of detail shown in this CES may not be readily available in the planning stage of a training p/c/d, when C-E analysis should be done. When system-specific data is lacking, generalized factors that may represent aggregations of cost elements are often used. These anomolies in Service practices and data availability suggest the use of this CES as a check list to identify gaps in essential data and the need for clearer definitions of existing data.

Advantages of a Comprehensive Cost Element Structure

The general use of a comprehensive cost element structure for military training, such as the one proposed in this paper, would offer several advantages for evaluating the costs of training programs, courses, and devices.

1. Used as a guide to estimate costs, it would ensure that all costs incurred during the life-cycle (or period of interest) of a training p/c/d would be accounted for. Gaps in essential data may be

[1]Section IV of this paper illustrates the applicability of this proposed cost element structure to a variety of training programs, courses, and devices.

identified in this way. Should the level of aggregation of available cost data not provide explicit information on every pertinent cost element, the source(s) of the data could, at least, be queried to determine whether those elements were included in the data that are available. Clearer definitions of such data would make it more useful.

2. This CES is a synthesis of cost analysis guidance issued for and by the weapon system and training communities of the Services and offices of the Secretary of Defense. As such, its general use should enhance communication and understanding among people concerned with training and those involved with other aspects of weapon system programs on subjects of mutual concern (e.g., cost estimates, trade-offs between cost and effectiveness, and the allocation of resources among mission areas, systems, and programs).

3. The level of detail should be adequate to identify the cost element(s) that account for the major costs of a training p/c/d. Identification of major costs, i.e., "cost drivers," would permit one to focus attention on areas for significant cost reduction or for trade-off analyses between high-cost items and effectiveness. It should also assist in identifying significant variables for use in the development of cost-estimating relationships.

4. It would permit making comparisons of costs among training options that are reliable and that can be used with confidence.

III. DEFINITIONS OF COST ELEMENTS

Definitions of the cost elements in Table 1, "A Comprehensive Cost Element Structure for Military Training Programs, Courses, and Devices," are presented in this Section. With the exception of the definitions of the cost elements that pertain to military and civilian personnel, the definitions are presented in the order in which they appear in Table 1.

Military personnel and civilian employees of the U.S. Government usually are associated with a training p/c/d throughout its life cycle. Accordingly, the cost elements that account for their employment appear many times under each of the life-cycle cost categories (R&D, Initial Investment, and Operating and Support) in this CES. To avoid repetition in these definitions, the costs of military and civilian personnel are defined first.

Personnel-associated costs are the largest expenditures in most training programs and courses. Because cost-effectiveness analyses often differ in scope and context, not all of these cost elements or their components will be applicable to every analysis; thus, care should be taken in the selection of relevant costs in order to avoid spurious and misleading results.

Pay and Allowances (P&A):

Military pay and allowances are the Standard Composite Pay Rates presented and explicitly defined in the DoD "Accounting Guidance Handbook." These pay rates include basic pay, incentive and special pay, basic allowance for quarters, and miscellaneous costs, each of which is also defined in the Handbook.

Civilian pay and allowances are roughly comparable to military Standard Composite Pay Rates. The Handbook and Air Force and Navy documents (Directorate of Cost and Management Analysis 1983, and Navy Personnel Research and Development Center 1980) provide the following breakdown:

a. Basic pay.

b. Additional variable payments for overtime, holiday pay, night differentials, and cost-of-living allowances.

c. Costs for employee benefits such as quarters allowance (when paid in cash), incentive awards, and the Service's share of payments of insurance, retirement,[1] FICA, taxes, and similar payments.

Other Government Personnel Costs:

Military Personnel:

PCS: The expense associated with a permanent change-of-station move, including household goods, dislocation allowances, and travel costs.

TDY: Includes transportation and per diem costs incurred for (a) business travel associated with a training p/c/d, and (b) students in attendance at short courses that do not require a PCS move.

Personnel Replacement: Includes the recurring costs of acquisition and prerequisite training of military personnel who will replace those now managing, operating, and supporting the training p/c/d, but who will be transferred to other duties or separated. Acquisition costs include recruiting costs (enlisted personnel only), in-processing, and initial outfitting. "Prerequisite training" is dictated by the skills required by the particular p/c/d(s) of interest.

[1]The Service's share of civilian employees' retirement pay equals the amount contributed by the employees from their basic pay.

Health Care: This element comprises the variable costs of health care provided at a higher echelon than operating-base level in support of military personnel associated with a training p/c/d.

Transients, Patients, and Prisoners: This element includes the variable costs of the P&A of military personnel added to the Services' strengths as increments to the number of personnel needed to fill spaces in formal Tables of Organization and Equipment. These increments are needed because not all personnel are available in units at all times. Transients are personnel on PCS between units, patients are long-term hospital cases, and prisoners are personnel committed to detention.

Family Housing: The net cost of housing furnished by the Service to the families of military personnel associated with a training p/c/d. Net cost is the difference between the basic allowance for quarters (a component of Standard Composite Pay Rate) foregone by military personnel who occupy government-furnished family housing and the Service's cost of that housing.

Retirement: Costs of military retirement pensions are funded by the DoD, not by the individual Services. The nature of a cost-effectiveness analysis (i.e., "cost to the Service" or "cost to the federal government") will dictate whether or not military retirement costs should be included.

Civilian Personnel:

PCS: (as for military personnel).

TDY: (as for military personnel).

Retirement: Includes only that portion of retirement pay of civil service employees which is funded from general revenues of the federal government. This element, therefore, is not applicable to analyses in which costs are constrained by Service or DoD budgets, but would be applicable if "cost to federal government" is pertinent.

A. RESEARCH AND DEVELOPMENT

Elements in the Research and Development (R&D) category include the costs of all hardware, software, other materials, people, and facilities necessary to create, test, and evaluate a training program, course, or device (or subsystem or major modification), that is qualified to specifications and acceptable for production (if hardware and software are components) or implementation.

1. Design: The costs of professional and technical personnel and miscellaneous materials and services required to design a training p/c/d and its components. Design activities may include preliminary and detailed analysis, the development of performance and characteristics specifications to meet operating requirements, the preparation of engineering drawings, and other documentation. The first three phases of Instructional System Development (ISD) (analysis of training requirements, definition of training requirements, and development of training objectives and tests)[1] are captured in this element. ISD costs should be separately identified.

a. Pay and Allowances:[2] The P&A of military and civilian government personnel involved in p/c/d design and ISD activities described above;[3] hence, the design function may require the services of people such as curriculum developers, media specialists, subject matter experts and instructors, as well as hardware and software engineers and technicians and logistics specialists.

b. Other Government Personnel Costs.[2] For personnel whose P&A are included in Design (A.1.a), above.

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[1]Department of the Air Force, Instructional System Development, 1975.

[2]Necessary definitions of Pay and Allowances and Other Government Personnel Costs are given at the beginning of this section.

[3]Note that the government personnel identified with most R&D functions (elements A.1 through A.7) are other than members of the "System/Project Management" team whose costs are included in element A.8.

c. Other: The costs of resources, other than government personnel, incurred in the design of a training p/c/d. Design work by contractors and non-personnel government costs (e.g., purchased services, miscellaneous materials) are included. The extent and scope of the design effort should dictate the degree to which this element is broken down.

2. Component Development: The costs to translate the results of design effort into components of a training p/c/d that meet design specifications. Component development includes the planning for, and the conduct and evaluation of, component tests (hardware; systems, applications, diagnostic/test, and utility software programs, instructional and other course materials; and course tests) and the subsequent redesign and iteration of these activities until a final design is achieved.

Because instructional materials may constitute the largest portion of development cost for training programs and courses that are not hardware-intensive, the costs of instructional materials should be explicitly broken down, whenever possible, as costs of particular "media materials" and "software" in the following elements (A.2.a, b, and c). Media materials are those that are to be presented to students (e.g., slides, filmstrips, workbooks, video discs, cassettes, movies, and any nonstandard equipment, requiring R&D, needed for their presentation). Software, as a component of instructional materials, is that needed to present course materials, manage student progress, and provide information relevant to the management of a course and its resources. Note that software as a component of instructional materials is distinct from other software that might be associated with other training device end-items (e.g., the software required in the fire-control subsystem of a trainer aircraft).

a. Pay and Allowances: The P&A of military and civilian government personnel involved in Component Development activities, as described above. These may include the people described in Design (A.1.a), in addition to development support (shop) personnel and managers who are identified with specific components.

b. Other Government Personnel Costs: For personnel whose P&A are included in Component Development (A.2.a), above.

c. Other: Same as Design, Other (A.1.c), except substitute "component development" for "design." In addition, non-personnel in-house costs may comprise, for example, raw and semi-finished materials, purchased parts and GFE consumed in component development, test equipment, and special tools.

3. Producibility Engineering and Planning: The cost incurred to insure the producibility of a developmental p/c/d, item or components of hardware and software (e.g., video discs), in an efficient and timely manner. Included are efforts related to development of quality assurance plans and special and unique manufacturing processes.

a. Pay and Allowances: The P&A of military and civilian government personnel involved in p/c/d producibility engineering and planning. This activity may require the services of the people in Design (A.1.a), above, as well as quality assurance and production engineers and technicians.

b. Other Government Personnel Costs: For personnel whose P&A are included in Producibility Engineering and Planning (A.3.a), above.

c. Other: Same as Design, Other (A.1.c), above, except substitute "producibility engineering and planning" for "design."

4. Tooling: Includes the costs of planning, design, fabrication, assembly, installation, modification and maintenance of the tools, fixtures, inspection and test equipment that support the development of training hardware components. Also includes the set of software programs that facilitates the development, test and validation of applications software.

a. Pay and Allowances: The P&A of military and civilian government personnel involved in developmental tooling, as described above. Typically, these people may include hardware component and manufacturing engineers, computer engineers and technicians, curriculum developers and media specialists, and development support personnel.

b. Other Government Personnel Costs: For personnel whose P&A are included in Tooling (A.4.a), above.

c. Other: Same as Component Development, Other (A.2.c), except substitute "tooling" for "component development."

5. Prototype Manufacturing: Includes the costs of all labor and materials specifically expended in the creation of a sufficient number of prototypes of major hardware and software components, and/or the training system in its entirety, for use in pre-acceptance test and evaluation. The costs of prototype spare parts, models, and mock-ups are also included in this element.

a. Pay and Allowances: The P&A of military and civilian government personnel who participate in producing and integrating the prototype hardware and software for use in P/C/D Test and Evaluation (A.7). They may include hardware and software component engineers and technicians, computer engineers and programmers, manufacturing and production engineers and specialists, and quality assurance and development support personnel.

b. Other Government Personnel Costs: For personnel whose P&A are included in Prototype Manufacturing (A.5.a), above.

c. Other: Same as Component Development, Other (A.2.c), except substitute "prototype manufacture" for "component development."

6. Data

a. Managerial Data: Includes the costs of collecting, reproducing, and distributing, throughout the R&D phase, reports and other documentation to support both contractor and Service program management. Excluded here are the costs of technical and analytical reports emanating from the Component Development (A.2) and P/C/D Test and Evaluation (A.7) functions, the costs of which are included in those elements.

(1) Pay and Allowances: The P&A of military and civilian government personnel who perform the services described in Data (A.6.a), above; principally, administrative support, graphics, and reproduction personnel.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Data, Managerial (A.6.a(1)), above.

(3) Other: Same as Design, Other (A.1.c), except substitute "managerial data" for "design."

b. Technical Data: Includes the costs of preparing, reproducing, and releasing to production, finalized engineering drawings, specifications, technical manuals, software documentation, and test plans and procedures. The costs of all earlier, iterative revisions to these data during R&D are included under Design (A.1), Component Development (A.2), and P/C/D Test and Evaluation (A.7).

(1) Pay and Allowances: The P&A of military and civilian government personnel involved in the preparation of technical data. This activity may require the diverse skills of technical writers, hardware and software engineers and specialists, graphic arts personnel, and logistics specialists.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Data, Technical (A.6.b(1)).

(3) Other: Same as Design, Other (A.1.c), except substitute "technical data" for "design."

7. P/C/D Test and Evaluation: This element comprises the costs of resources dedicated to the preparation, conduct, and evaluation of the results of developmental tests of the p/c/d as a whole.[1] Also included (explicitly identified) are the costs of completing the fourth phase of ISD, i.e., validation of the efficacy of instructional methods, media, devices, and tests. The costs of component test plans and tests and the actual test articles are excluded from this cost element; they are accounted for in cost elements A.2 Component Development, A.5 Prototype Manufacturing, and A.6.b Technical Data.

a. Pay and Allowances: The P&A of military and civilian government personnel who are directly involved in the test and evaluation (T&E) of the p/c/d as a whole. The nature of this activity may require, to some extent, the participation of many of the personnel mentioned in elements A.1 through A.6, above.

b. Other Government Personnel Costs: For personnel whose P&A are included in P/C/D Test and Evaluation (A.7.a).

c. Other: The costs of resources, other than government personnel, procured for and/or utilized in the T&E of a p/c/d as a whole. The costs of contractor-conducted T&E and

[1]This element can be equated to DT/IOT&E I and II in the development of a weapon system.

non-personnel government costs are included. These government costs may comprise new test equipment, consumables, range utilization, purchased services, etc.

8. System/Project Management: This element includes the cost of technical and business management effort expended by both the government and contractors in the process of developing an integrated training p/c/d. Excluded are the management costs that are identifiable with components of a p/c/d, and which are accounted for in all previous elements A.1 through A.7.

a. Pay and Allowances: The P&A of military and civilian government personnel involved in the technical and business management of a training p/c/d.

b. Other Government Personnel Costs: For personnel whose P&A are included in System/Project Management (A.8.a), above.

c. Other: Same as Design, Other (A.1.c), except substitute "system/project management" for "design."

9. Facilities: Includes the costs of new building(s), modification and expansion of existing facilities or sites, and facility maintenance and utilities attributable to the development of a training p/c/d and/or its components. Since R&D facility requirements can vary considerably among p/c/d's, these costs should be explicitly identified. [Facilities needed for implementing fully developed training p/c/d's are accounted for elsewhere (element B.9, Operational/Site Activation).]

10. Other: Any R&D costs not included above that are directly attributable to, or justifiably allocable to the training p/c/d or its components should be identified and included here. Examples might be contractor General and Administrative expenses and fees, license fees, and incentive payments and, if consequential, base operating support and military family housing.

B. INITIAL INVESTMENT

Elements in the Initial Investment category comprise the one-time costs of procuring and deploying p/c/d resources in the quantities needed to satisfy anticipated requirements (including attrition and wear-out).

1. Production

a. Nonrecurring: This group of elements comprises the costs of engineering and capitalization necessary to prepare for production of a training device[1] or components of a p/c/d at the rates and total quantity anticipated.

(1) Production Planning: The cost of engineering (and other technical) effort to determine the requirements for types and quantities of production tooling, equipment, quality assurance and production control procedures, make-or-buy decisions, and physical plant.

(2) Production Tooling and Equipment: Includes the cost of purchasing, fabricating, and installing the tools, jigs and fixtures, test equipment, etc., to support the manufacture of the hardware and software of a complete training device or p/c/d components.

(3) Industrial Facilities: Includes the costs of new building(s), modification and expansion of existing facilities, and the acquisition of real estate for the production of a training device or components of a p/c/d.

(4) Other: Any other nonrecurring costs attributable to, or justifiably allocable to, production of a training device or components of a p/c/d should be identified and included here.

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[1]In this context, a "training device" may be a unique computer, a simulator of operational or maintenance equipment, an aircraft, or any other device designed for, and dedicated to training.

b. Recurring: Elements in this group include the costs of activities and materials necessary to produce units of a training device or p/c/d components in the quantities required.

(1) Manufacturing: The costs of labor, materials [including Government-Furnished Equipment (GFE)], overhead, and any other charges incurred in the fabrication and assembly of p/c/d components (hardware and software), and integration of complete units.

(2) Sustaining Engineering: Comprises the cost of all engineering effort performed in support of production, including maintainability/reliability engineering, value engineering, production engineering, logistics engineering, and any other support engineering effort directly involved with production of p/c/d components or a training device as a whole [e.g., the maintenance, modification and updating of technical data, and the preparation of Engineering Change Proposals (ECP) and Engineering Change Orders (ECO)].

(3) Sustaining Tooling: The cost of maintenance, replacement or modification of tools, test equipment, and diagnostic/test/system software programs after the start of production.

(4) Quality Assurance: The cost of implementing the controls necessary to insure that manufacturing processes produce p/c/d components that meet prescribed standards. Included are costs of receiving, in-process and final inspections of materials, parts, assemblies, software; reliability testing, statistical analysis and related reports; and the conduct of production acceptance tests.

(5) Other: Any other costs identifiable with, or justifiably allocable to, recurring production of components and/or a p/c/d as a whole.

c. Initial Spares and Repair Parts: The cost of spare components, subassemblies and repair parts produced in the early stages of production for the maintenance of major end-items of p/c/d hardware and software until a normal flow of replenishment spares is established in the logistics pipeline.

2. Engineering Changes: Includes the costs of manufacturing, tooling and quality assurance labor, materials, and overhead to effect approved alterations to a training p/c/d and/or its components while it is still in the process of manufacture. The engineering costs incurred in preparing such changes are covered above in cost element B.1.b(2), Sustaining Engineering.

3. Purchased P/C/D-Peculiar Equipment: Includes the costs of secondary end-items purchased from vendors (e.g., peculiar support equipment, automatic test equipment software, or accessories). Such items are excluded from consideration in elements B.1.a(2), Production Tooling and Equipment and B.1.b(1), (2), and (3), certain Recurring Production costs.

4. Common Equipment: The cost of equipment usable for systems other than the p/c/d being costed but essential to its operation. For training p/c/d's, common equipment may include the costs of, e.g., additional desks, carrels, motion picture projectors, and some types of computers needed to support its use.

5. Data:

a. Managerial Data: Includes the costs of collecting, reproducing, and distributing, throughout the Initial Investment phase, reports and other documentation to support both contractor and Service program management.

(1) Pay and Allowances: The P&A of military and civilian government personnel who perform the services described

in Managerial Data, B.5.a , above; principally, administrative support, graphics and reproduction personnel.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Managerial Data, B.5.a (1).

(3) Other: The costs of resources, other than government personnel, incurred in producing managerial data for a training p/c/d. Contractor-produced managerial data and non-personnel government costs (e.g., purchased services, miscellaneous materials) are included.

b. Technical Data: Includes the costs of revising, reproducing in the quantities required for training p/c/d implementation, and distributing technical publications (e.g., technical orders, handbooks, manuals, and software documentation) for use in the field.

(1) Pay and Allowances: The P&A of military and civilian government personnel involved in the preceding activities. (Production and revision of technical data by contractor(s) would minimize government P&A.)

(2) Other Government Personnel Costs: For personnel whose P&A are included in Technical Data, B.5.b (1), above.

(3) Other: Same as Managerial Data, Other, B.5.a (3), except substitute "technical data" for "managerial data."

c. Instructional Materials: Comprises the costs of updating, reproducing in the quantities required for training course implementation, and distributing instructional information, tests, and guidance for instructors. Whenever possible, instructional material costs should be explicitly broken down as "media materials," "courseware," and "software." (See discussion under "Component Development," element A.2.)

(1) Pay and Allowances: The P&A of military and civilian government personnel involved in the activities described immediately above. Updating of instructional materials

may require the services of people such as media and subject matter experts and software specialists.

(2) Other Government Personnel Costs: For personnel whose P&A are in included in Data, Instructional Materials, B.5.c (1).

(3) Other: Same as Managerial Data, Other, B.5. a (3), except substitute "instructional materials" for "managerial data."

6. Training P/C/D Test and Evaluation: This element applies to the p/c/d as a whole. It includes the costs of all resources required to prepare for, conduct, and evaluate the results of T&E performed by the Service only.[1] The costs of complete unit(s) of a p/c/d and necessary test equipment for this T&E are included here only if it was not built and accounted for, previously, in Research and Development (elements A.5, Prototype Manufacturing, and A.7, P/C/D Test and Evaluation).

a. Pay and Allowances: The P&A of military and civilian government personnel who are directly involved in the T&E of the p/c/d as a whole. The nature of this activity may require, to some extent, the participation of people with skills similar to those mentioned in R&D elements A.1 through A.6, and Initial Investment elements Sustaining Engineering, B.1.b (2), Managerial Data, B.5.a (1), and Instructional Materials, B.5.c (1).

7. System/Project Management: Costs incurred during the Initial Investment phase for continuing the same functions costed in System/Project Management, A.8 under Research and Development.

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[1]This T&E activity approximates DT/OT III for a weapon system.

a. Pay and Allowances:

b. Other Government Personnel Costs:

c. Other:

8. Rents: The costs of leasing equipment, communications circuits, services, or material as part of the Initial Investment needed to establish a training p/c/d.

9. Operational/Site Activation: This element includes the costs of real estate, construction, conversion, utility provisions and plant equipment needed at organizational and intermediate levels to house, service and operate the training p/c/d. Depot-level facilities are excluded.

10. Initial Training:

a. Instructors: The cost of training the initial group of instructors who will train other instructors to implement and maintain a new or modified p/c/d. Included are the Pay and Allowances and Other Government Personnel Costs for instructors and student-instructors, and special instructional materials needed during the period of initial training.

b. Maintenance Personnel: The cost of training a cadre of personnel to maintain a new or modified training p/c/d at all echelons (organizational, intermediate, and depot levels). Included are the Pay and Allowances and Other Government Personnel costs of these trainees, and the special instructional materials required.

11. Transporation:

a. First-Destination: Includes the costs of moving components of a training p/c/d and its associated equipment from point of manufacture to Continental U.S. (CONUS) point of entry into the government's logistic network.

b. Second-Destination: Includes the costs of moving components of a training p/c/d from CONUS point of entry into the government's logistic network to operational sites either in the U.S. or overseas.

12. Other: Includes costs not captured in the foregoing elements that are identifiable with, or justifiably allocable to, the Initial Investment phase of a training p/c/d. Such costs should be individually enumerated.

C. OPERATING AND SUPPORT

Elements in the Operating and Support (O&S) category include the continuing costs of managing, operating, and maintaining units of a training p/c/d after they have been deployed for their intended use. Elements are grouped, by function, as direct and indirect costs.

1. Direct Costs: Elements in this group include the costs for resources that are specifically identified with, and involved in, the operation, maintenance, and management of a particular training p/c/d.

a. Instructional Costs: The expenses incurred in conducting a particular course of instruction which are directly identified with teaching, supervision, and administration at the course level, and the operation, maintenance and periodic modification of course-dedicated training devices and equipment.

(1) Pay and Allowances: The P&A of government personnel involved in the instructional activities described in Instructional Costs, C.1.a, above. Necessary definitions are given at the beginning of this section.

(a) Instructors: The P&A of military and civilian instructors for the time they devote to a particular training program or course.

(b) Supervisory, Administrative, and Support Personnel: Same as (a), preceding, for supervisory, administrative, and support personnel at the program or course level.

(c) Maintenance Personnel: The P&A of military and civilian personnel for the time they dedicate to the repair, modification, and routine maintenance of training device and equipment hardware. Note that this cost element pertains to organizational and intermediate levels of maintenance; depot maintenance is the subject of element C.1.a (6).

(2) Other Government Personnel Costs: For personnel whose pay and allowances are included in Direct, Instructional Costs, C.1.a (1), above. Necessary definitions are given at the beginning of this section.

(3) Consumption:

(a) Petroleum, Oils, and Lubricants (POL): The costs of fuels and lubricants needed for operating course-dedicated training devices and equipment.

(b) Training Munitions: The cost of ammunition, bombs, missiles, etc., allocated to a training course for expenditure.

(c) Utilities:

1. Electric Power: The cost of electric power needed to operate training devices and equipment, and for special requirements such as air conditioning for computer equipment.

2. Other: As required.

(d) Instructional Materials: The costs of replenishing stocks of texts, workbooks, films, supplies, and other materials used by instructors and students in a training course.

(e) Other: As required.

(4) Replenishment Spares: The cost of spare components and assemblies procured to maintain required stock levels in support of training devices or major end-items of equipment during the operational phase of a training p/c/d's life cycle.

(5) Modification Materiel: Includes the cost of items of materiel procured for the purpose of modifying training devices and equipment after acceptance by a military service. Labor costs for effecting modifications are excluded; they are covered by elements Maintenance Personnel, C.1.a (1)(c), Other Government Personnel Costs, C.1.a (2), and Labor and Materials, C.1.a (6)(a).

(6) Depot Maintenance:

(a) Labor and Materials: Includes the cost of military and civilian labor and miscellaneous materials for the repair, overhaul and modification of training device and equipment components and subsystems. Both organic- and contractor-performed depot maintenance are applicable here.

(b) Second-Destination Transportation: The cost of transportation of training devices, equipment, and their components and subsystems, between depot maintenance facilities and training installations.

(c) Other: As required.

(7) Other Purchased Services: The costs of leasing equipment, land, communications circuits, contractor services (other than depot maintenance), and material that are specifically identifiable with a particular program or course of instruction.

(8) Other: This element may include the costs for any other resources that are not designated in Direct, Instructional Costs, C.1.a (1) through (7), but which would be

consistent with the preceding definition of Instructional Costs. Such costs should be explicitly identified.

b. Training Activity Costs: The expenses incurred at the training activity (i.e., school or center headquarters) level for resources that are required for the management, administration, and other support of a number of courses, among which are the alternatives subject to cost-effectiveness analysis.

(1) Pay and Allowances: The P&A equivalent to the time devoted to a particular training program, course, or device by: the training activity commander and his immediate staff; personnel involved in functions such as student control and administration; flight safety, range maintenance, meteorology, communications, instructor training, and planning, programming, and resource management; and specialists who periodically review training standards, evaluate course content and results, improve training aids, and perform other course-associated services.[1] For courses in which modification of software and/or courseware is significant (e.g., computer-based instruction), the P&A of software/courseware specialists should be identified explicitly.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Training Activity Costs, C.1.b (1), above. Necessary definitions are given at the beginning of this section.

(3) Other: Includes the costs of resources at the training activity level, other than government personnel, that are incurred because a particular program or course is conducted within the training activity.

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[1]Ongoing improvement of course content is the final phase of ISD. It includes continuing evaluation, revision to reflect the results of evaluation, and periodic modification of software and courseware to accommodate changes in training requirements.

(a) Consumables: Includes the costs of general supplies, common training aids, utilities, and other similar items that are expended by the school or center headquarters in direct support of a program or course.

(b) Other: The costs of purchased services, leased equipment, and any other resources not specified in the preceding elements of Training Activity Costs, C.1.b, that are incurred at the training activity level for the conduct of a particular training p/c/d.

c. Airfield and Carrier Operations: This element covers only the costs incurred for airfield and carrier operations that are traceable to the conduct of a particular training program or course. Airfield and carrier operations include functions such as flight line communications, air traffic control, emergency services, aircraft security, and navigation aids.

(1) Pay and Allowances: That portion of the P&A of military and civilian personnel assigned to airfield and carrier operations that is attributable to a particular training p/c/d.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Airfield and Carrier Operations, C.1.c (1), above.

(3) Other: Non-personnel costs incurred for airfield and carrier operations that are justifiably attributable to a particular training program or course.

d. Student Costs: The personnel-associated costs of U.S. military and civilian personnel in training status.

(1) Pay and Allowances: The Standard Composite pay rates of the students. Necessary definitions are given at the beginning of this section.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Airfield and Carrier Operations, C.1.c (1), above.

(3) Other: Non-personnel costs incurred for airfield and carrier operations that are justifiably attributable to a particular training program or course.

d. Student Costs: The personnel-associated costs of U.S. military and civilian personnel in training status.

(1) Pay and Allowances: The Standard Composite pay rates of the students. Necessary definitions are given at the beginning of this section.

(2) Other Student Costs: For U.S. military and civilian students. Applicable costs are defined under "Other Government Personnel Costs" at the beginning of this section.

e. Other Direct Costs: This element is to include any direct operating and support costs, not accounted for above, that are attributable to the existence of the training p/c/d's of interest. Costs included in this element should be explicitly identified.

2. Indirect Costs: Elements in this group include the costs that may be incurred for resources which, although essential to support a particular training p/c/d, are not directly involved in its operation, maintenance, or management.

a. Base Operations: Includes the costs incurred by a host installation because a training program or course is located on that base. Examples of such activities are maintenance and utility costs for living quarters and mess facilities for individuals, transportation, supply, laundry, recreation, safety and security, and medical services. Military family housing is excluded here (see Military Family Housing Support, C.2.c).

(1) Pay and Allowances: The P&A of military and civilian personnel assigned to base operations activities in support of a particular training program or course.

(2) Other Government Personnel Costs: For personnel whose pay and allowances are included in Base Operations, C.2.a (1), above.

(3) Other: Non-personnel costs incurred by a host installation that are traceable to the location of a particular training p/c/d on that base.

b. Inventory and Supply Management: Includes the costs incurred above base level for ordering, stocking and distributing items of training p/c/d-associated hardware, software, courseware, and items that are required to support the military personnel identified with a p/c/d.

(1) Pay and Allowances: The P&A of military and civilian personnel who are engaged in the above activities at theater and depot levels.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Pay and Allowances, C.2.b (1), above.

(3) Other: As required.

c. Military Family Housing Support: Includes the net costs[1] of managing, operating and maintaining government housing occupied by families of military personnel associated with the conduct of a particular training program or course.

(1) Pay and Allowances: The P&A of military and civilian personnel devoted to the functions described in the preceding paragraph.

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[1]Net cost is the difference between actual cost and reimbursements provided by military personnel via forfeiture of basic allowance for quarters, which is a component of Pay and Allowances.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Housing Support, C.2.c (1), above.

(3) Other: Non-personnel costs (purchased services, materials, etc.) incurred for the operation and maintenance of family housing occupied by military personnel associated with the conduct of a training program or course.

d. Command Support Costs:[1] The costs of managerial support provided by major or intermediate command headquarters that are identifiable with a particular training p/c/d. These costs should include an appropriate share of the installation support provided to the command headquarters.

(1) Pay and Allowances: The P&A of military and civilian personnel at command headquarters whose efforts are devoted wholly, or in part, to an individual training p/c/d, and to an appropriate share of headquarters installation support.

(2) Other Government Personnel Costs: For personnel whose P&A are included in Command Support, C.2.d (1), above.

(3) Other: Non-personnel costs (purchased services, materials, etc.) incurred by command headquarters that are indentifiable with support of a particular training p/c/d and an appropriate share of headquarters installation support.

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[1]The Cost Analysis Improvement Group, OSD, advises the exclusion of Command Structure Overhead, which includes personnel assigned to, and the upkeep costs of, "...operating headquarters and staffs at and above the level of numbered Army, Air Force Air Division, Naval Air Wing, and Fleet Marine Force...." It is assumed that the resources of these headquarters would not vary perceptibly with the addition or deletion of the individual training p/c/d(s) under consideration.

e. Other Indirect Costs: This element is for any indirect operating and support costs, not accounted for above, that are attributable to the existence of the training p/c/d(s) of interest. Costs included here should be explicitly identified.

IV. APPLICATION OF PROPOSED COST ELEMENT STRUCTURE TO TRAINING PROGRAMS, COURSES, AND DEVICES

Table 2 was prepared to illustrate the applicability of each cost element in Table 1[1] to three types of training evaluated in previous studies, i.e., the cost-effectiveness of flight simulators, computer-based instruction, and maintenance simulators. The applicability of each cost element to each type of training was estimated as follows:

Applicability of Cost Element	Symbol
Always applicable.	+
May be applicable, depending on the context of the problem presented, assumptions, ground rules for the analysis, and characteristics of the training p/c/d of interest.	•
Not applicable.	(blank)

As should be expected, some functions and resources, and the costs associated with them, are essential to all training systems and, regardless of their size or complexity, certain costs would always be incurred. These include, for example, p/c/d design, test and evaluation, system/project management,

[1]Discrimination between military and civilian personnel, although an important characteristic of Table 1, is omitted from Table 2 because it is not essential to illustrate the general applicability of this cost element structure.

Table 2. ILLUSTRATIVE APPLICATION OF THE COMPREHENSIVE COST ELEMENT STRUCTURE FOR MILITARY TRAINING PROGRAMS, COURSES, AND DEVICES

COST CATEGORIES/ELEMENTS	ACADEMIC TRAINING				MAINTENANCE TRAINING		FLIGHT TRAINING		
	CONVENTIONAL (NO COMPUTERS)	INDIVIDUALIZED (NO COMPUTERS)	COMPUTER-BASED[a] COMPUTER-ASSISTED	COMPUTER-BASED[a] COMPUTER-MANAGED	ACTUAL EQUIPMENT	SIMULATOR[a]	AIRCRAFT TRAINER[b]	AIRCRAFT OPERATIONAL[c]	SIMULATOR[a]
A. RESEARCH AND DEVELOPMENT									
1. Design	+	+	+	+	+	+	+	+	+
2. Component Development	+	+	+	+	+	+	+	•	+
3. Producibility Engineering and Planning			•	•	•	+	+	•	+
4. Tooling			•	•	•	+	+	•	+
5. Prototype Manufacturing			+	+	+	+	+	•	+
6. Data									
a. Managerial	+	+	+	+	+	+	+	+	+
b. Technical	•	•	+	+	+	+	+	+	+
7. P/C/D Test and Evaluation	+	+	+	+	+	+	+	+	+
8. System/Project Management	+	+	+	+	+	+	+	+	+
9. Facilities			•	•	•	•	•	•	•
10. Other	•	•	•	•	•	•	•	•	•
B. INITIAL INVESTMENT									
1. Production									
a. Nonrecurring									
(1) Production Planning			•	•	+	+	+	•	+
(2) Production Tooling and Equipment			•	•	•	+	+	•	+
(3) Industrial Facilities	•	•	•	•	•	•	•	•	•
(4) Others	•	•	•	•	•	•	•	•	•
b. Recurring									
(1) Manufacturing			+	+	+	+	+	+	+
(2) Sustaining Engineering			+	+	•	+	+	+	+
(3) Sustaining Tooling			•	•	•	+	+	+	+
(4) Quality Assurance			•	•	+	+	+	+	+
(5) Other			•	•	•	•	•	•	•
c. Initial Spares and Repair Parts			+	+	+	+	+	+	+
2. Engineering changes			•	•	•	•	•	•	•
3. Purchased P/C/D-Peculiar Equipment			•	•	•	•	•	•	•
4. Common Equipment	•	•	•	•	•	•	•	•	•
5. Data									
a. Managerial	+	+	+	+	+	+	+	+	+
b. Technical	•	•	+	+	+	+	+	+	+
c. Instruction Materials	+	+	+	+	+	+	+	+	+
6. P/C/D Test and Evaluation	•	•	+	+	+	+	+	+	+
7. System/Project Management			•	•	+	+	+	•	+
8. Rents	•	•	•	•	•	•	•	•	•
9. Operational/Site Activation	•	•	•	•	•	•	•	•	•

[a]Assumes new hardware and/or software

[b]Designed, produced, and operated as a trainer.

[c]Essentially operational configuration and performance. May be used in primary mission role but used as trainer.

+ = Applicable

• = May be applicable; dependent upon context of problem presented, assumptions, and system characteristics.

(Blank) = Not applicable.

12-5-83-16

Table 2 (continued)

COST CATEGORIES/ELEMENTS	ACADEMIC TRAINING				MAINTENANCE TRAINING		FLIGHT TRAINING		
	CONVENTIONAL (NO COMPUTERS)	INDIVIDUALIZED (NO COMPUTERS)	COMPUTER-BASED[a] COMPUTER-ASSISTED	COMPUTER-BASED[a] COMPUTER-MANAGED	ACTUAL EQUIPMENT	SIMULATOR[a]	AIRCRAFT TRAINER[b]	AIRCRAFT OPERATIONAL[c]	SIMULATOR[a]
10. Initial Training									
a. Instructors	+	+	+	+	+	+	+	+	+
b. Maintenance Personnel			+	+	+	+	+	+	+
11. Transportation									
a. First Destination	•	•	•	•	•	+	+	+	+
b. Second Destination	•	•	•	•	•	•	•	•	•
12. Other	•	•	•	•	•	•	•	•	•
C. OPERATING AND SUPPORT									
1. Direct Costs									
a. Instructional Costs									
(1) Pay and Allowances									
(a) Instructors	+	+	+	+	+	+	+	+	+
(b) Supervisors, Administrative and Support Personnel	+	+	+	+	+	+	+	+	+
(c) Maintenance Personnel	•	•	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Consumption									
(a) POL					•		+	+	
(b) Training Munitions	•	•			•		+	+	
(c) Utilities									
1 Electric Power	•	•	+	+	+	+			+
2 Other	•	•	•	•	•	•	•	•	•
(d) Instructional Materials	+	+	+	+	+	+	+	+	+
(e) Other	•	•	•	•	•	•	•	•	•
(4) Replenishments Spares			+	+	+	+	+	+	+
(5) Modification Material			•	•	•	•	•	•	•
(6) Depot Maintenance			•	•	•	•	+	+	•
(a) Labor and Materials			•	•	•	•	+	+	•
(b) Second-Destination transportation			•	•	•	•	+	+	•
(c) Other			•	•	•	•	•	•	•
(7) Other Purchased Services	•	•	•	•	•	•	•	•	•
(8) Other	•	•	•	•	•	•	•	•	•
b. Training Activity Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+

[a]Assumes new hardware and/or software

[b]Designed, produced, and operated as a trainer.

[c]Essentially operational configuration and performance. May be used in primary mission role but used as trainer.

+ = Applicable

• = May be applicable; dependent upon context of problem presented, assumptions, and system characteristics.

(Blank) = Not applicable.

12-6-83-17

Table 2 (continued)

COST CATEGORIES/ELEMENTS	ACADEMIC TRAINING				MAINTENANCE TRAINING		FLIGHT TRAINING		
	CONVENTIONAL (NO COMPUTERS)	INDIVIDUALIZED (NO COMPUTERS)	COMPUTER-BASED[a] COMPUTER-ASSISTED	COMPUTER-BASED[a] COMPUTER-MANAGED	ACTUAL EQUIPMENT	SIMULATOR[a]	AIRCRAFT TRAINER[b]	AIRCRAFT OPERATIONAL[c]	SIMULATOR[a]
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
c. Airfield and Carrier Operations Costs									
(1) Pay and Allowances							•	•	
(2) Other Government Personnel Costs							•	•	
(3) Other							•	•	
d. Student Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Student Costs	+	+	+	+	+	+	+	+	+
e. Other Direct Costs	•	•	•	•	•	•	•	•	•
2. Indirect Costs									
a. Base Operations									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
b. Inventory and Supply Management									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
c. Military Family Housing Support	•	•	•	•	•	•	•	•	•
(1) Pay and Allowances									
(2) Other Government Personnel Costs									
(3) Other	•	•	•	•	•	•	•	•	•
d. Command Support Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
e. Other Indirect Costs	•	•	•	•	•	•	•	•	•

[a]Assumes new hardware and/or software

[b]Designed, produced, and operated as a trainer.

[c]Essentially operational configuration and performance. May be used in primary mission role but used as trainer.

+ = Applicable

• = May be applicable; dependent upon context of problem presented, assumptions, and system characteristics.

(Blank) = Not applicable.

12-8-83-18

instructional materials, initial training of instructors, base operations, students, instructors, and other management and support personnel.

Other functions and resources, however, are required for some, but not all, new training programs, courses, or devices. For example, initial investment costs associated with hardware and software production (e.g., manufacturing, sustaining engineering, tooling, and quality control) apply to simulators and aircraft designed exclusively for training, but are not applicable to conventional and individualized instruction in which computers are not utilized.

This degree of applicability (symbol •), indicating that a cost element may or may not be applicable, is liberally assigned. This is consistent with its definition. For example, the cost of training munitions [element C.1.a(3)(b)] is applicable in individualized markmanship training of combat troops, but may not be applicable in the academic training of zone-of-interior radar operators. Another example applies to several elements in the R&D category for operational aircraft used as trainers. Whether significant costs would be incurred for component development, producibility engineering and planning, tooling, and prototype manufacture would depend upon the degree to which operational aircraft would be modified for training purposes.

Although we acknowledge that the assessment of degree of applicability in Table 2 is, in part, judgmental, the table shows that a common cost element structure can be applied to the broad range of training programs, courses, and devices.

V. DISCUSSION

The main need for a definitive cost element structure relevant to military training is to enable consistent and credible evaluations of the cost and effectiveness of military training programs, courses, and devices. Once the costs can be specified and effectiveness measured or predicted, cost-effectiveness ratios can be computed for alternative training p/c/d's.

We have already pointed out that the level of detail in this structure permits people with interests in different aspects of training to focus on cost elements of primary concern to them. It must be noted, however, that attempts to optimize among selected cost elements without regard to related cost elements in the same, or other, cost categories can result in misleading conclusions. The following examples illustrate the importance of carefully considering the impact of <u>all</u> costs attributable to a training system, throughout its life cycle, even though it may not appear necessary to do so to answer a particular question.

Consider, for example, two ways of providing images of the outside world in a flight simulator or a tank gunnery simulator. Assuming that both techniques were equally satisfactory and the immediate concern was restraint in procurement costs (i.e., elements of the Initial Investment cost category), a decision might be made in favor of the alternative with the lower purchase price. Over the system's life cycle, however, the alternative that would result in lower procurement cost

might prove to be more costly if reliability were lower,[1] if electric power consumption were higher (element C.1.a(3)(c)1) and/or occasional modifications were more costly to accomplish (elements C.1.a(1)(c), C.1.a(2), C.1.a(5), and C.1.a(6)(a).

Another example concerns computer-based instruction and conventional classroom instruction. Computer-based instruction systems generally are characterized by higher acquisition costs (i.e., R&D plus Initial Investment) than are conventional classroom instruction systems. Viewing acquisition cost only, one might favor conventional instruction. Computer-based instruction, however, may be self-paced in nature, and can be employed to permit fast learners to complete courses in less time than is needed for conventional instruction; i.e., fast learners are not constrained by a pace set to meet the need of the average student. Considerable data show that computer-based instruction saves, on the average, 25 percent or more of the time students need to complete the same course given by conventional instruction. Conversely, over a given time period about 25 percent more students could complete a course that employs computer-based instruction. It follows that if the cost-per-student of competitive computer-based and conventional classroom courses are compared on a life-cycle cost basis, the higher acquisition costs of the computer-based training system might be more than offset in the operational phase. This outcome would not be revealed if analysis were limited only to consideration of acquisition costs.

Careful detailing of a work breakdown structure (WBS) of the training p/c/d components to which the cost element structure will be applied must be emphasized. For example, an analysis limited to the cost of computer hardware needed

[1]Lower reliability would cause higher maintenance and replenishment spares costs, reflected in elements C.1.a(1)(c), C.1.a(2), C.1.a(4), C.1.a(6), and C.2.b.

for computer-based instruction might show that acquisition costs have decreased markedly in recent years, and may continue to decrease in future years. It would be incorrect, however, to omit from the WBS the computer programs and course materials (software and courseware) needed for computer-based instruction. These products require highly skilled personnel and their costs have increased as much as, or more than, hardware costs have decreased. Similarly, in comparing computer-based instruction with conventional instruction, one might assume (incorrectly) that the costs of developing course materials would be the same for both methods of instruction and, therefore, could be omitted. A carefully constructed WBS, however, would include software as a component of the computer-based system, but not of conventional instruction, and courseware as a component of both.

Even though this paper is concerned only with the problem of identifying the costs of training p/c/d's, it is necessary to comment on the companion problem of determining the effectiveness of training p/c/d's. It makes little sense to select the least-cost alternative among several systems to satisfy a particular training requirement without regard to differences in effectiveness among the alternatives. Selection of the least-cost alternative in the interest of cost savings or cost avoidance might result in an unacceptably low level of effectiveness. The choice of another of the alternatives might be preferable if much greater effectiveness could be achieved with only slightly higher expenditures. Effectiveness could become the deciding factor, however, if the candidate p/c/d's were of approximately equal cost. This is not the place to discuss the effectiveness of training other than to say that both cost and effectiveness must be considered explicitly in analysis conducted to enable selection among alternative training programs, courses, or devices to fulfill a specific need. However, to do that will require another paper of this series.

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APPENDIX A

GLOSSARY OF TERMS RELEVANT TO COST ANALYSIS

CONSTANT DOLLARS vs. THEN-YEAR DOLLARS: Cost escalation (inflation) has been a fact of economic life for many years. The Congress, which authorizes Federal agencies to obligate and expend money, must think in terms of what a program will cost in future years as well as in the budget year under consideration; thus, Government agencies must provide for anticipated cost escalation when requesting program funding. Accordingly, budget requests for programs spanning several years include factors for escalation; that is, they are stated in terms of "then-year dollars." Cost estimates are usually presented in studies as "constant dollars," which are estimates in terms of money's value at a specified year. The use of "constant dollars" permits a more meaningful comparison of the monetary needs of competing systems with different time-phased funding profiles and provides a common base for escalation to then-year dollars.

COST AVOIDANCE reflects the reduction in costs of an existting system when it is retired or replaced by a new system.

COST-ESTIMATING RELATIONSHIP (CER) is a mathematical expression that relates cost to one or more physical or performance characteristics of an end-item. CERs usually are derived by simple or multiple regression analysis of historical cost data.

COST GROWTH denotes a pattern of increases in the cost of a system over what was previously estimated. For a number of reasons, the actual costs of weapon systems are virtually always substantially greater than Service or contractor estimates made during development. Accordingly, in studies involving the cost-effectiveness of weapon systems, current Service or contractor cost estimates of systems not yet deployed should reflect probable future cost growth. Accounting for probable cost growth is particularly important in studies involving the relative

costs and effectiveness of programs or systems at different stages of their lives. Use of Service or contractor cost estimates would tend to favor those systems in earlier stages of development relative to other systems in later stages of development or deployment. Three of the more common ways in which to correct current cost estimates for probable future cost growth are:

- Careful evaluation of Service and contractor estimates to identify omissions or understatements of cost elements.
- The use of CERs derived from data bases that reflect past costs of similar mature systems.
- Examination of cost growth histories of past programs for similar systems.

DISCOUNTING is a procedure that is used to account for the loss of investment potential by the private sector when monies are used by the Government to fund multi-year programs. Sometimes alternative courses of action by DoD have different time-phasing of the costs involved. In such cases future costs may be discounted to directly comparable present values. OMB Circular No. A-94 directs the use of discount rates in evaluating time-distributed costs. The prescribed discount rate at present (1982) is ten percent.

EXPENDITURES or OUTLAYS represent the spendout of obligational authority over the years necessary to complete the authorized transactions.

INHERITED ASSETS are multi-purpose assets which can be used by several military systems (e.g., airfield facilities). If multi-purpose assets are available, they may be passed on to or inherited by new systems without incurring obligational authority or expenditures. Inherited assets and the concept of

residual value are closely related; if an asset is inherited by a new system it necessarily had a residual value from its prior use.

THE LEARNING CURVE is used in estimating the procurement costs of major itmes of equipment (aircraft, missiles, etc.). It is a mathematical expression of the fact that the cost of a product decreases at some predictable rate as the quantity produced is increased. Originally recognized in the labor (man-hours) required to manufacture a product, the phenomenon has been found to apply to the cost of a manufactured product as a whole. As such, it may be more properly referred to as a "cost-improvement" or a "cost-quantity" curve.

LIFE-CYCLE COSTS are the total costs from the inception of a program or system to the end of its useful life (cradle-to-grave). There are two problems with this method of cost aggregation. First, it includes costs for all prior years. These costs are spent, or "sunk" and cannot be affected by decision-makers. The other problem is that the end of a system's useful life is highly speculative and usually it is not necessary to consider the phase-out period of a system in order to properly reflect the differences among alternative courses of action.

OPPORTUNITY COST is the value of resources that could be employed in two or more programs, but being assigned to one, denies the benefits of their use to other programs. The opportunity cost concept recognizes that resources are limited. Opportunity costs can reveal hidden costs that are not reflected in direct budgets; for example, use of government-owned facilities or land.

OUTLAYS (See EXPENDITURES, above).

PROGRAM ACQUISITION COST is the sum of R&D and Initial Investment costs of a military system.

PROGRAM COSTS are the total expenditures or Total Obligational Authority (TOA), by fiscal year, that would be incurred during a specific time period. The major advantage of aggregating costs by program costs is that they capture all of the expenditures or TOA required for a system over the time period of interest. Program costs consider equipment delivery schedules, deployment schedules, and periods during which systems would be introduced into, or phased out of, the inventory. Program costs in TOA are also the structure of costs presented in the Five-Year Defense Program (FYDP). Program costs differ from system costs in that program costs (a) include the operating and support costs during force build-up or phase-down, and (b) present the cost categories year-by-year rather than as totals.

RESIDUAL VALUE refers to the value that can be recaptured when a system is phased out. Sometimes material or facilities can be sold or diverted to other government use. Usually the residual value of a weapon system is neglible, but occasionally, as in the recycling of nuclear materials, it may be significant.

SUNK COST refers to costs already obligated or expended prior to the present time period. Sometimes present and near-term costs than cannot be affected by present decisions are also treated as sunk costs. Sunk costs normally have no bearing on current management decisions.

SYSTEM COSTS are the total of the R&D, initial investment, and some number of years (usually 10 or 15) of operating and support costs once a relatively constant level of activity of a

fully deployed force is reached. Thus, the aggregation of costs into system costs is an analytic convenience to simplify comparing the costs of two or more systems.

THEN-YEAR DOLLARS (See CONSTANT DOLLARS. . . ., above).

TOTAL OBLIGATIONAL AUTHORITY (TOA) represents authorization by Congress to obligate funds for expenditure in present and future years.

APPENDIX B

RELATIONSHIPS BETWEEN COST ELEMENTS FOR TRAINING AND DEPARTMENT OF DEFENSE BUDGET APPROPRIATIONS

The cost element structure (CES) developed in this paper is intended to capture all of the costs that might be incurred to develop, produce, conduct and maintain any military training program, course, or device (p/c/d) throughout its life cycle.

The funding required to fulfill the functions, activities and resources indicated by the cost elements is requested by the DoD from the Congress in a budget that is categorized as appropriations. The Congress, in turn, grants the DoD the authority to obligate and expend funds, by appropriation.

Knowledge of the relationships between these cost elements and the appropriations by which they would be funded is not essential to the purpose for which this CES was developed, i.e., estimating the cost-effectiveness of alternative training p/c/d's. It was felt, however, that it would be useful to identify the relationships between cost elements and appropriations (often called a "cross-walk") in order to facilitate communication among training and weapon system managers, cost analysts and budget analysts, and to make more visible to decisionmakers at various levels the impact of resource requirements on the funding needed for alternative training modes.

Table B-1 illustrates the cost element-to-appropriation cross-walk developed for the R&D cost category. The principal references used in its development include the DoD Budget Guidance Manual (July 1982), clarifying discussions with officials responsible for budget appropriations policy in the office of the Deputy Assistant Secretary (Program/Budget), and the cost element definitions in Section III of this paper. Personnel of the Services' training management headquarters[1] also were consulted to determine funding sources for Instructional System Development activities and resources.

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[1] Chief of Naval Education and Training, Pensacola, Florida; Air Force Air Training Command, Randolph AFB, Texas; and Army Training and Doctrine Command, Fort Monroe, Virginia.

The first and third columns identify the cost elements that are the subjects of Table 1 and Section III. The second column refers to the Notes at the end of Table B-1, which support the association of resources and their sources of funding. Generally, the notes comprise synopses of applicable sections of the Budget Guidance Manual and discussions with officials of the Services' training management headquarters.

The cost elements shown in the third column include resources required to fulfill various functions needed to develop training p/c/d's. For some extensive and costly training p/c/d's (e.g., a new trainer aircraft) the list of In-House resources may be incomplete; for relatively low-cost p/c/d's (e.g., group classroom instruction) the list may be too extensive. Table B-1 was developed, however, with all p/c/d's in mind, and illustrates the fact that the association of cost elements and the budget appropriations by which they would be funded is a function of the resources required to perform the functions indicated by the descriptive titles of the cost elements.

It appears that the association of cost elements and budget appropriations cannot be standardized for all training p/c/d's. This exercise indicates that it is feasible to formulate a cross-walk that is applicable to all training p/c/d's; however, differences in the kinds of resources needed among training p/c/d's, the post-R&D disposition of those resources, and the organizations by which the work is done, suggest that such a cross-walk is not a useful tool for management analysis. For this reason, cross-walks for the Initial Investment and Operating and Support cost categories were not developed. If a cross-walk is desired for planning and budgeting purposes, it probably would be done best with specific information on how and by whom each training p/c/d would be accomplished.

Table B-1. COST ELEMENTS AND RELATED BUDGET APPROPRIATIONS FOR RESEARCH AND DEVELOPMENT OF TRAINING PROGRAMS, COURSES, AND DEVICES

Cost Element Ident.	Applicable Notes	Cost Elements	Budget Appropriations
A.1.		Design	
A.3.		Producibility Engrg. & Planning	
A.6.		Data (Managerial & Technical)	
A.8.		System/Project Management	
		In-house	
	1	Military Personnel	
	2	Civilian Personnel	
		Other	
	3	Purchased Services	
	3	Misc. Materials	
	3	Contractor	
A.2.		Component Development	
		In-house	
	1	Military Personnel	
	2	Civilian Personnel	
		Other	
	3,6	Purchased Services	
	4,6	Materials	
	3,4,6	Purchased Parts	
	5	GOE	
	3,4,5	Test & Inspection Eqpmt.	
	3	Special Tools	
	3,6	Contractor	
A.4.		Tooling	
		In-house	
	1	Military Personnel	
	2	Civilian Personnel	
		Other	
	3	Purchased Services	
	3,4	Materials	
	3,4	Purchased Parts	
	5	GOE	
	3,4,5	Test & Inspection Eqpmt.	
	3	Special Tools	
	3,6	Contractor	

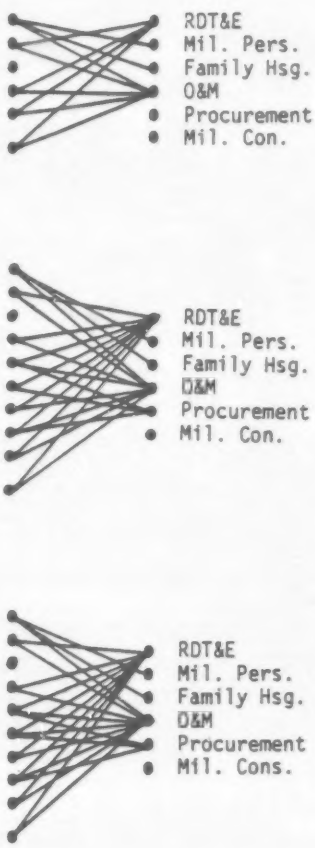
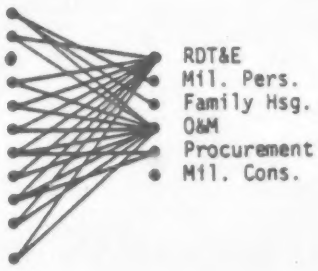
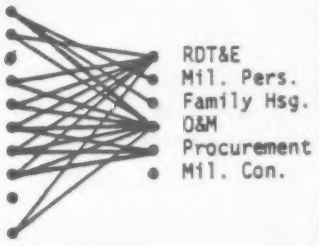


Table 8-1 (continued)

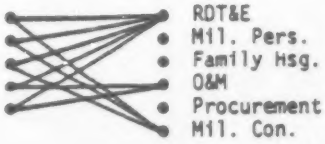
A.5.		Prototype Manufacturing	
		In-house	
	1	Military Personnel	
	2	Civilian Personnel	
		Other	
	3	Purchased Services	
	3	Raw & Semi-finished Matls.	
	3	Misc. Materials	
	3,4,6	Purchased Parts	
	5	GOE	
	3,4,5	Test & Inspection Eqpmt.	
	3	Special Tools	
	3	Contractor	



A.7.		P/C/D/ Test and Evaluation	
		In-house	
	1	Military Personnel	
	2	Civilian Personnel	
		Other	
	3	Purchased Services	
	3	Misc. Materials	
	3,4	Consumables	
	3	Range/Airfield/Carrier Utilization	
	3,4,5	Test Equipment	
	7	Munitions	
	3	Contractor	



A.9.	8	Facilities	
		Construction	
		Modification	
		Installation	
		Maintenance	
		Utilities	



NOTES:

1. The P&A and PCS costs for military personnel are funded by the Military Personnel (Mil Pers) appropriation. Other military personnel costs (TDY, health care, personnel replacement, and transients, patients, and prisoners) are funded by the Operations and Maintenance (O&M) appropriation. The costs of government-owned family housing (construction, furnishings, and maintenance) occupied by military personnel are paid from the Family Housing appropriations. These cost element

Table B-1 (continued)

and appropriation relationships hold, regardless of the training function or activity in which military personnel are engaged or their duty assignments (e.g., manager, administrator, instructor, student, technician) [Deputy Assistant Secretary of Defense (Program/Budget)].

2. The costs of civilian (civil service) personnel engaged in training R&D activities may be funded by the RDT&E or the O&M appropriations. The choice depends upon the source of funding of the organization by which they are employed. The costs of civilian employees of the Air Force's Deputy for Simulators (SIMSPO), for example, are funded by the RDT&E appropriation because the SIMSPO is an office of the Air Force Systems Command, which is an R&D organization. On the other hand, civilian employees of the Air Force Air Training Command (ATC) are funded from O&M because the costs of ATC's activities are defrayed principally by the O&M appropriation [Deputy Assistant Secretary of Defense (Program/Budget) and FYDP, January 1983].

3. The guidance for funding civilian personnel (i.e., a function of the source(s) of funding available to the organization conducting the R&D) also may apply to other resources required to fulfill the functions of some cost elements. Purchased parts, purchased services, and R&D work by contractors, for example, might be funded either by RDT&E or O&M appropriations [Program Development Center, CNET, August 1983; U.S. Army TRADOC, July 1983; Cost and Management Analysis, USAF ATC, July 1983].

4. Articles (including end items, weapons, equipment, components, and materials) of types regularly procured to meet established general requirements, but which are used in support of RDT&E-funded R&D programs, may be financed by Procurement appropriations if they are not consumed in R&D. The RDT&E appropriation would bear the costs of articles consumed in R&D, and the costs of returning used articles to serviceable condition for other use [Budget Guidance Manual, July 1982, p. 251-5]. Note that this guidance applies specifically to RDT&E-funded programs (e.g., trainer aircraft and large simulators), but it also is adopted for O&M-funded R&D such as ISD for computer-based instruction.

Table B-1 (continued)

5. Major end items (such as weapons, test vehicles, equipment, or major components thereof) made available from existing inventory for the R&D phase of a training program, course, or device will not be charged to RDT&E unless they are consumed in R&D. RDT&E will finance the costs of returning such items to serviceable condition for further use [Idem, p. 251-6]. (Substitute "O&M" for "RDT&E" for R&D efforts that are financed by O&M appropriations.)

6. Training devices that employ new or off-the-shelf computers and components, but have unique software and interface components, will be purchased and developed with RDT&E funds [Idem, p. 251-10].

7. Consumable rounds of ammunition or tactical missiles procured for inventory may be issued for use in R&D testing without reimbursement (unless reimbursement is specifically required) [Idem, p. 251-6].

8. The Military Construction appropriations fund acquisition, construction and installation above the $100,000 threshold. The acquisition or construction of industrial facilities at government-owned (government- or contractor-operated) R&D installations or activities will be funded by RDT&E appropriations if the cost is less than $100,000. RDT&E appropriations also finance, to the $100,000 limit, the costs associated with the installation of equipment or instrumentation in an RDT&E-financed government facility; however, the RDT&E appropriations do not fund any installation costs if installation work is accomplished concurrently with a Military Construction-funded project [Idem, p. 251-1, -2, -3].